REMARKS

Prior to the present amendment and response, claims 1-2, 4-9, 17, 19-20, 22, 26-27, 29, and 31-36 were pending in the present application. By the present amendment and response, claims 1, 9, 17, 20, 26, 27, and 35 have been amended to overcome the Examiner's objections. Thus, claims 1, 2, 4-9, 17, 19-20, 22, 26-27, 29, and 31-36 remain in the present application. Reconsideration and allowance of pending claims 1, 2, 4-9, 17, 19-20, 22, 26-27, 29, and 31-36 in view of the above amendments and the following remarks are requested.

A. Rejection of Claims 17, 20, and 27 under 35 USC §112, first paragraph

The Examiner has rejected claims 17, 20, and 27 under 35 USC §112, first paragraph. Applicant has amended claims 17, 20, and 27 and submits that the requirements of 35 USC §112, first paragraph, have been met.

B. Rejection of Claims 1-2, 6, 9, 19, 22, 26, 29, 33, and 35 under 35 USC §103(a)

The Examiner has rejected claims 1-2, 6, 9, 19, 22, 26, 29, 33, and 35 under 35 USC §103(a) as being unpatentable over U.S. patent number 3,761,319 to John Martin Shannon (hereinafter "Shannon") in view of U.S. patent number 3,581,164 to Pfander et al. (hereinafter "Pfander"). For the reasons discussed below, Applicant respectfully submits that the present invention, as defined by amended independent claims 1, 9, 26,

and 35, is patentably distinguishable over Shannon and Pfander, singly or in combination thereof.

The present invention, as defined by amended independent claims 1 and 26, includes, among other things, selecting a first peak dopant concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of a varactor device is optimized, forming a first implant in an epitaxial layer using the first implant energy, and forming a second implant in the epitaxial layer using a second implant energy and having a second peak dopant concentration, where the first and second implants are situated over a buried layer, and where the second peak dopant concentration has a depth that is greater than a depth of the first peak dopant concentration.

As disclosed in the present application, first and second implants are formed in an epitaxial layer in an implant region of a semiconductor substrate, where the first and second implants have respective first and second peak dopant concentrations, and where the first and second implants are situated over a buried layer formed in the semiconductor substrate. As disclosed in the present application, by appropriately selecting the first peak dopant concentration and first implant energy of the first implant, the present invention advantageously achieves a double-implant varactor device having at least an optimized capacitance, leakage current, or tuning range.

Also, as disclosed in the present application, by appropriately selecting the second peak dopant concentration and the second implant energy such that the second implant is

disposed below the first implant, the present invention achieves a double-implant varactor having minimized base resistance and, consequently, an optimized Q. Thus, present invention advantageous achieves a varactor wherein all of the varactor's parameters, i.e. capacitance, leakage current, tuning range, and base resistance, can be advantageously optimized by appropriately selecting the first and second peak dopant concentrations and first and second implant energies of first and second implants, respectively.

In contrast, Shannon does not teach, disclose, or suggest selecting a first peak dopant concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of a varactor device is optimized, forming a first implant in an epitaxial layer using the first implant energy, and forming a second implant in the epitaxial layer using a second implant energy and having a second peak dopant concentration, where the first and second implants are situated over a buried layer, and where the second peak dopant concentration has a depth that is greater than a depth of the first peak dopant concentration. Shannon specifically discloses p- silicon substrate 81, buried n+ region 86 situated in p- silicon substrate 81, and p- epitaxial layer 83 situated over buried n+ region 86. See, for example, Figure 9 and related text of Shannon.

In Shannon, boron ions that are implanted through a previously diffused emitter concentration of phosphorus deter emitter/base junction 99 and a more highly doped portion 100 of the base region directly below the emitter region. See, for example, column 14, lines 56-75, column 15, lines 1-3, and Figure 11 of Shannon. However, Shannon fails to teach, disclose, or remotely suggest selecting a first peak dopant

concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of a varactor device is optimized, forming a first implant in the epitaxial layer using the first implant energy, and forming a second implant in the epitaxial layer using a second implant energy and having a second peak dopant concentration, where the first and second implants are situated over the buried layer, and where the second peak dopant concentration has a depth that is greater than a depth of the first peak dopant concentration, as specified in amended independent claims 1 and 26.

In contrast, Pfander does not teach, disclose, or suggest selecting a first peak dopant concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of a varactor device is optimized, forming a first implant in the epitaxial layer using the first implant energy, and forming a second implant in an epitaxial layer using a second implant energy and having a second peak dopant concentration, where the first and second implants are situated over a buried layer, and where the second peak dopant concentration has a depth that is greater than a depth of the first peak dopant concentration. Pfander specifically discloses forming base region 4 within epitaxial layer 2, which is deposited on intermediate layer 6 (i.e. a buried layer), forming emitter region 5 within the marginal area of base region 4. See, for example, column 3, lines 53-75, column 4, line 1, and Figure 2 of Pfander.

In Pfander, region 8 is formed within the marginal surface area of emitter region 5 and extends from emitter region 5 through base region 4 and epitaxial layer 2 to, and within the marginal area of, intermediate layer 6 (i.e. a buried layer). See, for example,

column 4, lines 1-4 and Figure 2 of Pfander. On page 5 of the Office Action dated May 3, 2005, the Examiner states that it is well known in the art to form a second P-type region (8) beneath the emitter region (5) and to select a peak dopant concentration such that at least one of capacitance, leakage current, and tuning range of the varactor devise is optimized. However, in Pfander, region 8 extends into intermediate layer 6 (i.e. a buried layer). In contrast to Pfander, amended independent claims 1 and 26 specify forming a second implant in an epitaxial layer, where the second implant is situated over a buried layer.

Also, as shown in Figure 2 of Pfander, the doping concentration of region 8 has peak concentration N_{IO} at the surface of epitaxial layer 2 and decreases with increasing depth. Similarly, the doping concentration of base region 4 has peak concentration N_{BO} at the surface of epitaxial layer 2 and decreases with increasing depth. Thus, Pfander fails to teach, disclose, or suggest forming first and second implants over a buried layer, where the first implant has a first peak dopant concentration and the second implant has a second peak dopant concentration, and where the second peak dopant concentration has a depth that is greater than a depth of the first peak dopant concentration, as specified in amended independent claims 1 and 26. Furthermore, in Pfander, epitaxial layer 2 and intermediate layer 6 (i.e. a buried layer) both have N type conductivity. In contrast, as specified in amended independent claims 1 and 26, the epitaxial layer has a first conductivity type and the buried layer has a second conductivity type. Thus, the structure taught in Pfander is significantly different than the structure as specified in amended

independent claims 1 and 26. Thus, Pfander fails to cure the basic deficiencies of Shannon discussed above.

For the foregoing reasons, Applicant respectfully submits that the present invention, as defined by amended independent claims 1 and 26, is not suggested, disclosed, or taught by Shannon and Pfander, singly or in combination thereof. As such, the present invention, as defined by amended independent claims 1 and 26, is patentably distinguishable over Shannon and Pfander. Thus claims 2 and 6 depending from independent claim 1 and claims 29 and 33 depending from amended independent claim 26 are, *a fortiori*, also patentably distinguishable over Shannon and Pfander for at least the reasons presented above and also for additional limitations contained in each dependent claim.

Amended independent claims 9 and 35 recites similar limitations as amended independent claims 1 and 26. Additionally, amended independent claims 9 and 35 recite, among other things, selecting a second peak dopant concentration and a second implant energy with relation to a first peak dopant concentration and a first implant energy such that the base resistance of a varactor device is minimized. As discussed above, Shannon and Pfander fail to teach, disclose, or remotely suggest forming first and second implants over a buried layer, where the first implant has a first peak dopant concentration and the second implant has a second peak dopant concentration, and where the second peak dopant concentration has a depth that is greater than a depth of the first peak dopant concentration. Thus, for at least the reasons discussed above, amended independent

claims 9 and 35 are also patentably distinguishable over Shannon and Pfander. Thus claims 19 and 22 depending from amended independent claim 9 are, *a fortiori*, also patentably distinguishable over Shannon and Pfander for at least the reasons presented above and also for additional limitations contained in each dependent claim.

C. Rejection of Claims 4-5, 7-8, 31-32, and 34 under 35 USC §103(a)

The Examiner has rejected claims 4-5, 7-8, 31-32, and 34 under 35 USC §103(a) as being unpatentable over Shannon in view of Pfander, and further in view of IBM Corporation (NN79013241), "Determination of Doping Profiles by Means of SIMS," IMB Technical Disclosure Bulletin, 1979, Vol. 21, Issue Number 8, pp. 3241-3242. As discussed above, amended independent claims 1 and 26 are patentably distinguishable over Shannon and Pfander. Thus claims 4-5 and 7-8 depending from amended independent claim 1 and claims 31-32 and 34 depending from amended independent claim 26 are, *a fortiori*, also patentably distinguishable over Shannon and Pfander for at least the reasons presented above and also for additional limitations contained in each dependent claim.

D. Rejection of Claims 17, 20, 27, and 36 under 35 USC §103(a)

The Examiner has rejected claims 17, 20, 27, and 36 under 35 USC §103(a) as being unpatentable over Shannon in view of Pfander, and further in view of U.S. patent application publication number 2002/0014650 A1 to Hirotoshi Kubo. As discussed

above, amended independent claims 9, 26, and 35 are patentably distinguishable over Shannon and Pfander. Thus claims 17 and 20 depending from amended independent claim 9, claim 27 depending from amended independent claim 26, and claim 36 depending from amended independent claim 35 are, *a fortiori*, also patentably distinguishable over Shannon and Pfander for at least the reasons presented above and also for additional limitations contained in each dependent claim.

E. **Additional cited art**

The Examiner has cited Japanese patent application number JP 56026477 A to Nobuhiro Minotani (hereinafter "Minotani"), Japanese patent application number JP 56042381 A to Enosawa et al. (hereinafter "Enosawa"), and Japanese patent application number JP 04343479 A to Igarashi et al. (hereinafter "Igarashi") as pertinent to Applicant's disclosure. Minotani specifically discloses a varactor including P type region 12 and N type regions 15, 17, and 19 formed in N type layer 11, which is grown on N type substrate 10. Enosawa specifically discloses a variable capacity diode including N type layer 8 situated on an N type substrate and N type region 9 situated adjacent to N type region 10 formed in N type layer 8. Igarashi specifically discloses a variable capacitance diode including P type diffusion layer 7 formed in N type diffusion layer 6, which is formed in N type silicon substrate 1.

However, Minotani, Enosawa, and Igarashi do not teach, disclose, or suggest selecting a first peak dopant concentration and a first implant energy such that at least one

of capacitance, leakage current, and tuning range of a varactor device is optimized, forming a first implant in an epitaxial layer using the first implant energy, and forming a second implant in the epitaxial layer using a second implant energy and having a second peak dopant concentration, where the first and second implants are situated over a buried layer, and where the second peak dopant concentration has a depth that is greater than a depth of the first peak dopant concentration, as specified in amended independent claims 1, 9, 26, and 35. Thus, Applicant respectfully submits that the present invention, as defined by amended independent claims 1, 9, 26, and 35, is patentably distinguishable over Minotani, Enosawa, and Igarashi.

F. Conclusion

Based on the foregoing reasons, the present invention, as defined by amended independent claims 1, 9, 26, and 35, and claims depending therefrom, is patentably distinguishable over the art cited by the Examiner. Thus, claims 1, 2, 4-9, 17, 19-20, 22, 26-27, 29, and 31-36 pending in the present application are patentably distinguishable over the art cited by the Examiner. As such, and for all the foregoing reasons, an early Notice of Allowance for claims 1, 2, 4-9, 17, 19-20, 22, 26-27, 29, and 31-36 pending in the present application is respectfully requested.

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Respectfully Submitted,
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